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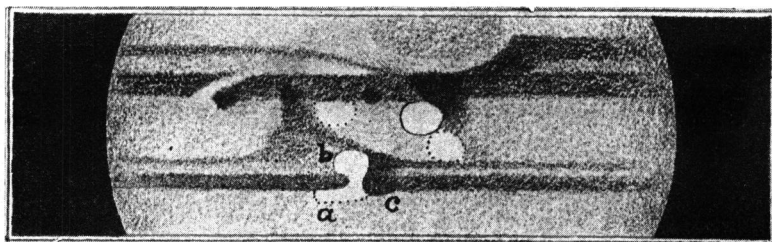


FIG. 1. 1898, *March 31.*

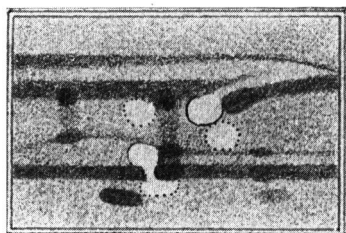


FIG. 2. *April 5.*

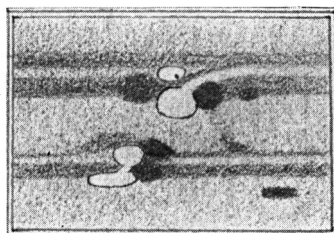


FIG. 3. *April 12.*

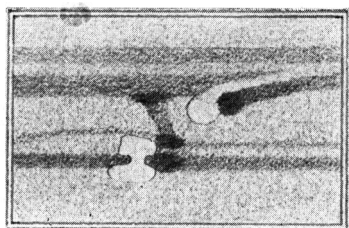


FIG. 4. *May 7.*

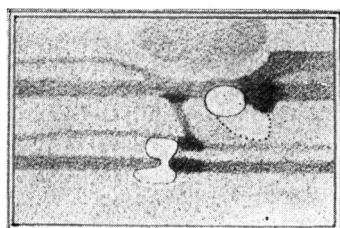


FIG. 5. *May 14.*

DRAWINGS OF *JUPITER*.  
BY A. STANLEY WILLIAMS.

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THE NORTHERN BORDER OF THE EQUATORIAL  
CURRENT OF *JUPITER*.

BY A. STANLEY WILLIAMS.

It is well known that the equatorial regions of *Jupiter* are occupied by a surface current having a very high velocity compared with that of the districts immediately adjoining it on the north and south. The difference in velocity, about two hundred and fifty miles an hour, is so great, in fact, that the spots or other markings situate near the equator gain as much as five minutes on those lying just outside the current in each rotation of the planet. In other words, the equatorial spots will return to the same position on the disc, the meridian passing through the center, for instance, five minutes sooner than the extra-equatorial ones. As *Jupiter* makes two and a half of his rotations in one of our terrestrial days, the difference amounts to nearly thirteen minutes per day. The motion of an equatorial spot is so rapid that an interval of only four days is required for it to drift the length of the well-known Red Spot, the position of which is still clearly marked by the deep hollow, or bay, in the south equatorial belt opposite to it, though the spot itself is extremely faint at the present time. It is sometimes a highly interesting sight to watch day by day a conspicuous string of bright and dark spots, such as are so often to be found on the north side of the south equatorial belt, drift in solemn procession past the Red Spot.

At the present time there are some very important questions requiring investigation in connection with the borders of this equatorial current, and the complicated system of rifts, streamers, and spots characterizing these regions. The *average* boundary of the current may be said to fall nearly at the middle points of the two

great equatorial belts. Thus, referring to the accompanying sketch (Fig. 1), the average southern boundary lies in the bright rift separating the components of the double south equatorial belt; and the average northern boundary falls about the middle of the north equatorial belt, which at the date of the sketch was single, though it likewise is generally double. Outside these limits the surface markings rotate at a rate not differing very greatly from that of the Red Spot. Inside, all markings belong to and move with the swift equatorial current. The line of demarcation is usually very sharp, without much indication of any transition stage between the currents, the velocities of which, as already mentioned, differ by about two hundred and fifty miles an hour. Hence it is not surprising to find various important and complex changes occurring in and about the borders of the equatorial current.

The *average* boundaries of the current are as indicated above, but actually considerable variations occur in their positions from time to time. This is particularly the case with regard to the northern limit. In 1887 and the succeeding five or six years, the northern boundary fell at, or, at any rate, very close to, the extreme south edge of the north equatorial belt. In other words, this prominent dark belt was then situate *outside* of the equatorial current altogether. At most, only a narrow strip at its extreme southern edge was included in the current. Last year, however, a very remarkable change had occurred, resulting in the whole of the north equatorial belt being included *within* the equatorial current, which indeed actually extended a little north of that belt. This change is indeed so very remarkable, that it seems desirable to place on record without delay the evidence by which it is established.

My observations of *Jupiter* last year commenced on February 27th. On that night I noticed a white spot on the north side of the north equatorial belt, and it was noted as being in mid-transit across the disc at  $12^{\text{h}} 37^{\text{m}}.5$ . No particular attention was attracted by the spot at the time, as similar spots have nearly always been very common in this locality, and it was at the time considered, like these, to rotate at a rate not differing greatly from that of the Red Spot.

But on March 20th a rather peculiar group of spots was observed, consisting of a white spot on the north side of the belt, connected by means of a bright rift *through* the belt, with a white

spot on the south side of the latter. Immediately following was a dark double spot. The appearance presented by the two white spots connected by the bright rift through the belt was very striking, and on the first available occasion the region was re-examined, in order to see what, if any, changes had taken place. This occasion presented itself on March 29th, when the configuration seemed unaltered, and on March 31st the sketch (Fig. 1) was made. It will be seen that the appearance still remained practically the same as it had been on March 20th and March 29th, so that the whole group evidently rotated at one and the same rate; this rate, moreover, being that of the equatorial current. The group of spots was observed on many occasions in the course of the next three months, during which period its appearance remained substantially unaltered, as will be seen by the accompanying sketches. At my last observation, on June 1st, the aspect of the group was still unchanged. It was also found on subsequent investigation that the white spot which I had observed on the north side of the belt on February 27th was identical with that marked *a* in Figure 1, though at the time neither the white spot *b* nor the connecting rift were noticed, probably owing to the indifferent seeing prevailing then. The dark spot *c* had, however, been observed.

In the following tables I have brought together the observed times when the three spots, *a*, *b*, and *c*, of Figure 1, were in mid-transit across the disc. In some cases the double-spot *c* may have been observed as one object, whilst in others the time may relate to the transit of a single component; but the two spots were situate so nearly north and south that any differences arising from this would be very slight. Column 3 contains the corresponding longitudes of the spots according to *System I* of Mr. CROMMELIN's "Ephemeris for Physical Observations of *Jupiter*," published in the *Monthly Notices*.\* The fourth column gives the residuals according to the rotation periods stated below, which periods appear to represent satisfactorily the observations of the different spots. In the last column, D.=W. F. DENNING, Bristol; M.=H. MACEWEN, Glasgow; P.=T. E. R. PHILLIPS, Yeovil, Somerset; W.=A. S. WILLIAMS. The times are all Greenwich mean times.

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\*The rotation period of *System I* is 9<sup>h</sup> 50<sup>m</sup> 30<sup>s</sup>.

WHITE SPOT *a.*

1899.		Transit.	Longitude.	O—C	Observer.
		h. m.	°	m.	
Feb.	27	12 37.5	128.0	— 4.2	W.
Mar.	20	10 31.3	129.8	+ 2.2	"
	29	10 56.7	127.5	0.0	"
	31	12 9.3	127.8	+ 0.8	"
Apr.	5	10 16.8	129.3	+ 4.0	"
	12	9 29.5	126.4	+ 0.5	"
	16	11 52	125.2	— 0.9	"
	21	9 58.3	125.7	+ 0.7	"
	23	11 6.6	123.3	— 2.9	"
May	7	9 41	122.0	— 2.8	"
	16	10 16	124.1	+ 2.2	"

WHITE SPOT *b.*

Mar.	20	10 31.3	129.8	— 1.4	W.
	29	10 59.7	129.4	— 0.5	"
	31	12 12.3	129.7	+ 0.4	"
Apr.	5	10 14	127.6	— 2.1	P.
	"	10 14.3	127.8	— 1.8	W.
	12	9 32	128.0	— 0.3	P.
	"	9 35.5	130.1	+ 3.2	W.
	16	11 55	127.1	— 0.9	"
	21	10 0.3	127.0	— 0.2	"
	23	11 9.7	125.2	— 2.8	"
	30	10 35.8	130.1	+ 6.5	"
May	7	9 43	123.2	— 3.4	"
	9	10 57.8	124.6	— 0.9	"
	14	9 1	122.1	— 3.1	P.
	"	9 10.2±	128.3±	(+ 6.1)	W.
	16	10 17	124.8	+ 0.7	"
	"	10 20	126.6	+ 3.7	P.
	21	8 27.5	127.3	+ 5.8	"
June	1	10 5	122.8	+ 0.4	W.
	22	7 58	118.6	— 2.5	D.

DARK SPOT *c.*

Feb.	27	12 59.5	141.4	+ 0.6	W.
Mar.	20	10 46.3	138.9	— 1.5	"
	29	11 15.7	139.2	— 0.4	"
	31	12 32.3	141.9	+ 4.3	"
Apr.	5	10 34.8	140.3	+ 2.1	"
	12	9 51.5	139.8	+ 1.9	"
	16	12 9	135.6	— 4.6	"
	17	7 53	137.5	— 1.4	D.
	21	10 18.3	137.9	— 0.3	W.

1898.		Transit.		Longitude. °	O—C m.	Observer.
		h.	m.			
Apr.	23	11	29.8	137.4	— 0.9	W.
	30	10	47.8	137.4	— 0.4	"
May	7	10	3.5	135.8	— 2.5	"
	9	11	13.3	134.0	— 5.1	"
	14	9	24.7	137.1	+ 0.4	"
	"	9	25	137.3	+ 0.7	P.
	16	10	36.5	136.7	— 0.2	W.
	"	10	41	139.4	+ 4.3	P.
	"	10	41	139.4	+ 4.3	M.
June	21	8	42.5	136.5	— 0.1	P.
	15	9	5	135.0	+ 0.2	"
	22	8	23	133.9	— 1.4	"

The approximate rotation periods of the three spots are:—

$$\begin{aligned}
 \text{Spot } a &= 9^{\text{h}} 50^{\text{m}} 26^{\text{s}}.0 \text{ (190 rotations)} \\
 \text{" } b &= 9 \ 50 \ 25.5 \text{ (229 " )} \\
 \text{" } c &= 9 \ 50 \ 27.8 \text{ (280 " )}
 \end{aligned}$$

the mean period of the group being  $9^{\text{h}} 50^{\text{m}} 26^{\text{s}}.4$ .

The presence of the white spot *a* on the north side of the north equatorial belt shows clearly that in 1898 the equatorial current extended north of the belt, but the actual boundary was only a small distance to the north of the northern edge of the belt. This is indicated by the presence of a number of dark spots just north of the belt, which spots rotated at a rate not differing very greatly from that of the Red Spot. Two of them are shown in Figure 2, the most preceding of the two appearing again in Figure 3.\* It will be seen that on April 5th the group of spots *a*, *b*, *c* was just following the last-mentioned spot, but on April 12th it preceded the latter by a long interval. I was in hopes of catching the white spot *a* when in the act of drifting past one of these dark spots, but bad weather always interfered at the critical time.

The permanency of aspect of the group of spots is rather remarkable, since it appears that little or no change of importance occurred during an interval of more than three months, either in its appearance or rate of motion. During this period considerable changes of aspect and some curious shifts in position occurred in some of the spots on the north side of the

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\* The spots are represented as isolated, but they actually were situated on a fine belt in good seeing, appearing like beads strung on a thread. The mean rotation period of the three plainest spots was  $9^{\text{h}} 55^{\text{m}} 26^{\text{s}}.3$ , according to Mr. W. F. DENNING.

south equatorial belt shown in the accompanying sketches, but the disturbances producing these do not seem to have extended to the group of spots about the north equatorial belt.

This permanency of aspect is significant. The north equatorial belt is occasionally the seat of most abnormal and intense disturbance. These occasions of abnormal disturbance seem to arise when the northern boundary of the equatorial current falls on or within the belt. By reason of the two conflicting currents, the dark material of the belt is then literally torn to shreds, resulting in innumerable spots, streaks, and detached fragments, which undergo rapid changes. This state of things occurred in 1896-97, and again during the late opposition (1899). The belt appears to be in a comparatively quiescent state if it is situated either wholly without the equatorial current, as in 1887 and the succeeding five or six years; or within it, as was the case in 1898. Not but what there are always very many spots and other details visible about the belt, but the changes which then take place are comparatively slow and inconsiderable.

The rapid drift of the equatorial spots past the Red Spot alluded to above is illustrated by the present sketches. Figure 1 shows the group of spots on the north equatorial belt under the preceding end of the Red Spot, and in Figure 5 the group appears again in nearly the same relative position. But in the interval between March 31st and May 14th the group of spots has made very nearly a complete circuit of the planet relative to the Red Spot.

This rapid drift of the equatorial spots ought to be well known by now, but it is nevertheless only too common to find even observers of considerable experience still endeavoring to identify spots near the equator from their position relative to the Red Spot, or in the system of longitudes representing approximately the motion of the latter (*System II* of Mr. CROMMELIN'S ephemeris).

HOVE, SUSSEX (Eng.), 7th September, 1899.

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